UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/815,033	03/31/2004	Christophe J. Dorrer	9-10-7-9	7803

46363 7590 04/14/2009

WALL & TONG, LLP/
ALCATEL-LUCENT USA INC.
595 SHREWSBURY AVENUE
SHREWSBURY, NJ 07702

EXAMINER	
LIU, LI	
ART UNIT	PAPER NUMBER
2613	

MAIL DATE	DELIVERY MODE
04/14/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/815,033	DORRER ET AL.	
	Examiner	Art Unit	
	LI LIU	2613	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *31 December 2008*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *2-10,12-14,19-23,25,26,28 and 29* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *2-10,12-14,19-23,25,26,28 and 29* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *31 March 2004* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Response to Arguments

1. Applicant's arguments with respect to claims 2-10, 12-14, 19-23, 25, 26, 28 and 29 have been considered but are moot in view of the new ground(s) of rejection.

1). Applicant's argument – "the Office Action asserts that in the combination of Chraplyvy and Hodzic, a two-bit delay interferometer must be used to decode the APol-DPSK signal", "In order to combine the advantages of DPSK with alternate polarization, it is not the only solution to differential phase shift key between two optical bits separated by an even number of bit periods and to demodulate the APol-DPSK signal using an even bit delay line interferometer, as taught by Applicants and as claimed in independent claim 10".

Examiner's response – As admitted by the applicant, some conventional methods to implement the alternate polarization include time division multiplexing and polarization multiplexing. These methods need polarization controller, OTDM multiplexer and polarization combiner etc, the transmitter and receiver are complicated. Hodzic teaches a simpler method to implement the alternate polarization format: a phase modulator (or polarization modulation) is used to directly rotate the polarization of the optical pulse based on the bit rate. No time division multiplexing and polarization multiplexing are needed. And the system performance is significantly improved.

As the polarization modulator as taught by Hodzic is applied to the DPSK format of Chraplyvy et al, that is to combine a polarization modulator with the phase modulator (105 in Figure 3 of Chraplyvy), the outputs from the polarization modulator have

alternate polarization: the bits 1, 3, 5, … 2n-1 have one kind of polarization, and the bits 2, 4, 6, … 2n has another polarization which is orthogonal to the polarization of “odd” bits. That is, the two sets of data bits can be treated independently; and since bit “1” and bit “3” has a two-bit periods of time interval, to get the DPSK benefit and restore the original data, the bits 1, 3, 5, … 2n-1 need to be encoded by differentially phase shift keying between any two bits separated by two-bit slots (or even number of bit periods), so to generate “odd” bits conventional DPSK signal, same is for bits 2, 4, 6, … 2n. At the receiver, theoretically, the “odd” bits and the “even” bits do not interfere (or coherently add or subtract) with each other at the balanced detector because they are orthogonally polarized. Therefore, the demodulator with two bits delay is needed. That is why the examiner states that a two-bit delay interferometer is needed to decode the APol-DPSK signal. By directly modulating the polarization of the optical pulse and encoding the signal using DPSK with two bits delay, a simpler alternate polarization system can be obtained; and the time division multiplexing/demultieplxing and polarization multiplexing/demultiplexing and polarization controller etc are not needed, the system cost can be reduced.

2). Applicant’s argument – “Heismann does not teach modulating an optical signal according to a precoded electronic data signal by differential phase shift keying between two optical bits separated by an even number of bit periods wherein said modulating and said polarization alternating are performed simultaneously by a Mach-Zehnder modulator including a polarization rotation device in at least one arm”.

Examiner's response – Heismann et al teaches a Mach-Zehnder modulator including a polarization rotation device (the 90 degree Rotated PMF in Figure 2) in at least one arm, and the Mach-Zehnder modulator can provide simultaneous polarization alternation and optical phase modulation (Figure 2, equations (5), (7) and (10) etc., page 313-314). As disclosed by Heismann, the phase difference between the two arms in Figure 2a or 2b is introduced by the phase modulation signal applied to the two arms. After the phase modulation, one arm is rotated 90 degree to make the polarization states of the components in the two arms orthogonal. The output Jones vectors of the device in Figure 2(a) is shown in Equations (5) and (10). The functional operation of the polarization alternator in Figure 2(a) is <u>similar to that of a phase modulator followed by a variable polarization rotator</u>. Heismann et al teaches that by varying the two drive voltage amplitude and the relative drive phase, <u>any desired combination of polarization and phase modulation can be produced</u>, and the phase relationship between the induced polarization and phase modulation can also be controlled (page 314, right column). Since Chraplyvy et al and Snawerdt teaches to precode the electronic signal by differential phase shift keying, and the Mach-Zehnder modulator of Heismann can generate any desired phase modulation and polarization state, with the combination of Chraplyvy et al and Hodzic and Snawerdt and Heismann, the Mach-Zehnder modulator of Heismann can be driven according to the precoded electronic signal of differential phase shift keying with two bit delay so to provide simultaneously polarization alternation and phase encoding to generate the APol-DPSK signal.

3). Applicant's argument – "The 90 degree rotated PMF is a "polarization maintaining fiber" (defined in Heismann p. 312 col. 2 second to last paragraph), and is clearly not a half-wave plate. Thus, Heismann fails to teach or suggest a Mach-Zehnder (MZ) modulator device optically coupled to an optical source having a half-wave plate in one arm, as positively recited in Applicants' independent claim 26".

Examiner's response – The 90 degree rotated PMF is not just a "polarization maintaining fiber", it is a "90 degree rotated polarization maintaining fiber" (also refer to page 313 left column: rotate the optical axis of one of the PMF connectors by 90 degree such that one of the two TM-polarized waves is converted into a TE-polarized wave). It is commonly known or textbook knowledge that a half-wave plate is an optical device that alters the polarization state of a light wave traveling through it: retards one polarization by half a wavelength, or rotates the polarization direction of linear polarized light by 90 degree. That is, the "90 degree rotated PMF" is a half-wave plate that is made of a piece of polarization maintaining fiber. The applicant does not disclose what specific half-wave plate in the claim 26 is, what specific material or structure constitutes the half-wave plate. The claim does not exclude a half-wave plate that is made of a piece of polarization maintaining fiber. Actually, in another publication (Xie et al: "Suppression of Intrachannel Nonlinear Effects With Alternate-Polarization Format", Journal of Lightwave Technology, Vol. 22, No. 3, March 2004, pages 806-812. Figure 3), the applicant uses exactly the same polarization alternator as Heismann disclosed, and the PMF with 90 degree rotation is the half-wave plate (comparing the Figure 4C of the application with the Figure 3b of Xie et al). Therefore, Heismann teaches or

suggests a Mach-Zehnder modulator device optically coupled to an optical source having a half-wave plate in one arm.

Claim Rejections - 35 USC § 103

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

3. Claims 4, 10 and 29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chraplyvy et al (US 2003/0007216) in view of Hodzic et al (Hodzic et al: "Improvement of System Performance in N x 40-Gb/s WDM Transmission Using Alternate Polarizations", IEEE Photonics Techmology Letters, Vol. 15, No. 1, Jan 2003, pages 153-155) and Snawerdt (US 2002/0093713).

1). With regard to claim 10, Chraplyvy et al discloses a method comprising:

modulating an input optical signal (Figure 3, the optical signal from the DFB laser) according to a precoded electronic data signal (Figure 3, the modulator 105 drove by the precoded electronic data from the Differential Encoder 313) by differential phase shift keying between two adjacent optical bits to generate an encoded optical signal ([0026], the encoder 313 is a differential phase shift keying encoder, and the PSK modulator 105 output the DPSK optical signal as shown in Figure 4e);

demodulating the DPSK signal using one bit delay line interferometer (the demodulator 501 in Figure 5).

But, Chraplyvy et al does not disclose: the modulator is drove by a precoded electronic data signal by differential phase shift keying between two optical bits separated by an even number of bit periods; and alternating the polarization of the encoded optical signal using a modulator such that successive optical bits have substantially orthogonal polarizations to generate an APol-DPSK signal; and demodulating the APol-DPSK signal using an even bit delay line interferometer.

However, it is well known in the art that the alternate polarization format with adjacent bits have orthogonal polarization can be used to significantly reduce the intrachannel nonlinear distortion. Hodzic teaches such a method to generate APol-RZ signal (alternate polarization return-to-zero signal) (Figure 1). Hodzic et al teaches a RZ coder, modulating the input optical signal by the RZ electronic data signal, alternating the polarization of the RZ optical signal using a modulator (polarization modulator in Figure 1) such that successive optical bits have substantially orthogonal polarizations to generate an APol-RZ signal.

Hodzic discloses that the APol-RZ signals with orthogonal polarization between adjacent bits cause significant improvement of system performance through suppression of non-linear effects compared with RZ and NRZ format, the APol-RZ modulation format significantly improves the maximum input power, shows 7-10 dB improvement compared to RZ and NRZ format, the alternate polarization of adjacent bits reduces the power transfer between adjacent bits resulting also in suppression of intrachannel effects; and the APol-RZ possesses better PMD characteristics than RZ and NRZ, has better dispersion tolerance; the maximum transmission distance can be

enhanced with factor of 2 by using this modulation method. Hodzic et al teaches that the alternate polarization format remains the best choice modulation format (page 155 left column).

As the polarization modulator as taught by Hodzic is applied to the DPSK format of Chraplyvy et al, that is, combine a polarization modulator with the phase modulator (105 in Figure 3 of Chraplyvy), it is obvious to one skilled in the art that the differential encoder (e.g., 313 in Figure 3) needs to be set as a two-bit delay precoder and the demodulator (501 in Figure 5) needs to be a two-bit delay line interferometer: after the polarization modulator, the bits 1, 3, 5, … 2n-1 have one kind of polarization, and the bits 2, 4, 6, … 2n has another polarization which is orthogonal to the polarization of “odd” bits; at the receiver, theoretically, the “odd” bits and the “even” bits do not interfere (or coherently add or subtract) with each other at the balanced detector because they are orthogonally polarized. That is, the two sets of data bits can be treated independently; since bit “1” and bit “3” has a two-bit periods of time interval, to get the DPSK benefit and restore the original data, the bits 1, 3, 5, … 2n-1 need to be encoded by differentially phase shift keying between any two bits separated by two-bit slots (or even number of bit periods), so to generate “odd” bits conventional DPSK signal, same is for bits 2, 4, 6, … 2n. And to decode the DPSK signal or restore the original data, the 2-bit delay interferometer is needed since each set of data is encoded by two-bit delay at the transmitter.

To precode the data by two-bit delay is not new in the art; theoretically, the conventional DPSK format can be generate with differentially phase shift keying

between any two bits separated by one bit slot, two-bit slots or other number of bit slots as long as the demodulator has the same number of bit delay. Snawerdt, in the same field of endeavor, teaches a system and method to generate a DPSK format with a precoder having delay of 2-bit slots (18 in Figures 1 and 2 generates the differential phase shift keying electronic signal, “OP” as shown in Figure 4 and 5, [0040] and [0046]), the precoded signal drives the phase modulator (16 in Figure 1), and an DPSK optical signal (encoded with two bits separated by two bits) is outputted from the phase modulator (22 in Figure 1, or [0046], phase modulator 16 converts the electronic data stream OP into optical signal 22 representative of OP); and a two-bit delay interferometer (40 in Figures 1 and 3) to demodulate the differential phase shift keying signal and restore the original input data signal (DSO as shown in Figures 3-5).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the alternate polarization format and two-bit delay precoder and demodulator as taught by Hodzic et al and Snawerdt to the system of Chraplyvy et al so that a APol-DPSK modulation format can be obtained, and the intrachannel nonlinear distortion can be reduced, and system performance can be significantly enhanced, and the transmission distance can be significantly increased.

2). With regard to claim 4, Chraplyvy et al and Hodzic et al and Snawerdt disclose all of the subject matter as applied to claim 10 above, and the combination of Chraplyvy et al and Hodzic et al and Snawerdt further discloses wherein the input optical signal is provided into the modulator having a polarization oriented at a predetermined angle (Hodzic: page 153, the optical signal is launched into the

polarization modulator having a polarization oriented at $\pi/4$) such that the polarization of successive optical bits of the transmitted APol-DPSK signal are substantially orthogonal (Hodzic teaches that the polarization of the adjacent bits are orthogonal; that is, the combination of Chraplyvy and Hodzic and Snawerdt teaches that the polarization of successive optical bits of the APol-DPSK signal are substantially orthogonal).

3). With regard to claim 29, Chraplyvy et al discloses an optical transmission system (Figures 3- 5) for DPSK transmission comprising:

an optical source (the DFB Laser 101 in Figure 3);

a precoder device (the Differential Encoder 313 in Figure 3) for precoding an electronic data signal;

an optical phase-shift-keying data modulator (the phase modulator 105 in Figure 3) optically coupled to the laser source and driven by a precoded electronic data signal from the precoder device to produce an optical DPSK signal (Figure 4e, and the output from the PSK modulator 105);

a demodulator (501 in Figure 5) comprising an one bit delay line interferometer.

But, Chraplyvy et al does not disclose: an APol-DPSK transmission, wherein electronic data to be transmitted is optically encoded by the data modulator as differential phase shift keying between two optical bits separated by an even number of bit periods; a polarization alternator optically coupled to the data modulator to provide polarization alternation of the output of the data modulator to produce an APol-DPSK signal; and the demodulator comprising an even bit delay line interferometer.

However, it is well known in the art that the alternate polarization format with adjacent bits have orthogonal polarization can be used to significantly reduce the intrachannel nonlinear distortion. Hodzic teaches such a method to generate APol-RZ signal (alternate polarization return-to-zero signal) (Figure 1). Hodzic et al teaches an APol-RZ transmission, wherein electronic data to be transmitted is optically encoded by the RZ modulator (MZI in Figure 1a); a polarization alternator (the Polarization Modulator in Figure 1a) optically coupled to the data modulator to provide polarization alternation of the output of the data modulator to produce an APol-RZ signal.

Hodzic discloses that the APol-RZ signals with orthogonal polarization between adjacent bits cause significant improvement of system performance through suppression of non-linear effects compared with RZ and NRZ format, the APol-RZ modulation format significantly improves the maximum input power, shows 7-10 dB improvement compared to RZ and NRZ format, the alternate polarization of adjacent bits reduces the power transfer between adjacent bits resulting also in suppression of intrachannel effects; and the APol-RZ possesses better PMD characteristics than RZ and NRZ, has better dispersion tolerance; the maximum transmission distance can be enhanced with factor of 2 by using this modulation method. Hodzic et al teaches that the alternate polarization format remains the best choice modulation format (page 155 left column).

As the polarization modulator as taught by Hodzic is applied to the DPSK format of Chraplyvy et al, that is, combine a polarization modulator with the phase modulator (105 in Figure 3 of Chraplyvy), it is obvious to one skilled in the art that the differential

encoder (e.g., 313 in Figure 3) needs to be set as a two-bit delay precoder and the demodulator (501 in Figure 5) needs to be a two-bit delay line interferometer: after the polarization modulator, the bits 1, 3, 5, … 2n-1 have one kind of polarization, and the bits 2, 4, 6, … 2n has another polarization which is orthogonal to the polarization of “odd” bits; at the receiver, theoretically, the “odd” bits and the “even” bits do not interfere (or coherently add or subtract) with each other at the balanced detector because they are orthogonally polarized. That is, the two sets of data bits can be treated independently; since bit “1” and bit “3” has a two-bit periods of time interval, to get the DPSK benefit and restore the original data, the bits 1, 3, 5, … 2n-1 need to be encoded by differentially phase shift keying between any two bits separated by two-bit slots (or even number of bit periods), so to generate “odd” bits conventional DPSK signal, same is for bits 2, 4, 6, … 2n. And to decode the DPSK signal or restore the original data, the 2-bit delay interferometer is needed since each set of data is encoded by two-bit delay at the transmitter.

To precode the data by two-bit delay is not new in the art; theoretically, the conventional DPSK format can be generate with differentially phase shift keying between any two bits separated by one bit slot, two-bit slots or other number of bit slots as long as the demodulator has the same number of bit delay. Snawerdt, in the same field of endeavor, teaches a system and method to generate a DPSK format with a precoder having delay of 2-bit slots (18 in Figures 1 and 2 generates the differential phase shift keying electronic signal, “OP” as shown in Figure 4 and 5, [0040] and [0046]), the electronic data (DSI in Figures 2,4 and 4) to be transmitted is optically

encoded by the data modulator (the phase modulator 16 in Figure 1) as differential phase shift keying between two optical bits separated by an even number of bit periods ([0036]); the precoded signal drives the phase modulator (16 in Figure 1), and an DPSK optical signal (encoded with two bits separated by two bits) is outputted from the phase modulator (22 in Figure 1, or [0046], phase modulator 16 converts the electronic data stream OP into optical signal 22 representative of OP); and a two-bit delay interferometer (40 in Figures 1 and 3) to demodulate the differential phase shift keying signal and get the original input data signal (DSO as shown in Figures 3-5).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the alternate polarization format and two-bit delay precoder and demodulator as taught by Hodzic et al and Snawerdt to the system of Chraplyvy et al so that a APol-DPSK modulation format can be obtained, and the intrachannel nonlinear distortion can be reduced, and system performance can be significantly enhanced, and the transmission distance can be significantly increased.

4. Claims 2, 3 and 5-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chraplyvy et al and Hodzic et al and Snawerdt as applied to claim 10 above, and in further view of Heismann et al (Heismann et al: “High-Speed Polarization Scrambler with Adjustable Phase Chirp”, IEEE Journal of Selected Topic in Quantum Electronics, Vol. 2, No. 2, June 1996, page 311-318).

1). With regard to claims 2 and 3, Chraplyvy et al and Hodzic et al and Snawerdt disclose all of the subject matter as applied to claim 10 above, and Hodzic et al further discloses that the modulation is performed by a phase modulator driven by a RF clock

signal (Figure 1b). But, Chraplyvy et al and Hodzic et al and Snawerdt do not expressly disclose wherein the modulation is performed by a phase modulator driven by a sinusoidal RF voltage, or driven by a train of square pulses.

However, it is well known in the art that the clock signal can be sinusoidal signal or a train of square pulses. And in Figure 4c, Chraplyvy et al discloses that a square-wave shape pulse can be used to drive the phase modulator. Another prior art, Heismann teaches that the polarization modulator is a phase modulator driven by a sinusoidal RF voltage (Figures 1 and 2).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply either a sinusoidal RF voltage or a train of square pulses to the phase modulator of the system of Chraplyvy et al and Hodzic et al and Snawerdt so that the desired polarization and phase modulation can be obtained.

2). With regard to claims 5 and 6, Chraplyvy et al and Hodzic et al and Snawerdt disclose all of the subject matter as applied to claim 10 above, But Chraplyvy et al and Hodzic et al and Snawerdt does not expressly discloses wherein the modulaton is performed by a Mach-Zehnder modulator including a polarization rotation device in at least one arm; and wherein the polarization rotation device is a half-wave plate.

However, Heismann et al teaches a polarization modulator (Figure 2), wherein the modulator is a Mach-Zehnder modulator including a polarization rotation device (the 90 degree Rotated PMF) in at least one arm; and wherein the polarization rotation device is a half-wave plate (the half-wave plate is made of a 90 degree rotated PMF,

and the half-wave plate retards one polarization by half wavelength or π phase retardation, so to rotate the polarization by 90 degree).

Heismann et al teaches a modulator for high speed polarization and phase modulation. Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the high-speed modulator as taught by Heismann to the system of Chraplyvy et al and Hodzic et al and Snawerdt so that a high-speed alternate polarization DPSK system can be obtained.

3). With regard to claims 7 and 8, Chraplyvy et al and Hodzic et al and Snawerdt and Heisman et al disclose all of the subject matter as applied to claims 10 and 5 above, and Hodzic et al further discloses that one arm of the phase modulator is driven by a RF clock signal at half the bit rate (20 GHz clock signal, 40 Gb/s data signal). But, Chraplyvy et al and Hodzic et al and Snawerdt do not expressly disclose wherein the Mach-Zehnder modulator is a phase modulator driven by a sinusoidal RF voltage, or driven by a train of square pulses at half the bit rate.

It is well known in the art that the clock signal can be sinusoidal signal or a train of square pulses. And in Figure 4c, Chraplyvy et al discloses that a square-wave shape pulse can be used to drive the phase modulator. And Heismann teaches that the polarization modulator is a phase modulator driven by a sinusoidal RF voltage (Figures 1 and 2). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply either a sinusoidal RF voltage or a train of square pulses to the phase modulator so that desired polarization and phase modulation can be obtained.

5. Claims 12-14, 19-23 and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chraplyvy et al (US 2003/0007216) in view of Hodzic et al (Hodzic et al: "Improvement of System Performance in N x 40-Gb/s WDM Transmission Using Alternate Polarizations", IEEE Photonics Techmology Letters, Vol. 15, No. 1, Jan 2003, pages 153-155) and Snawerdt (US 2002/0093713) and Heismann et al (Heismann et al: “High-Speed Polarization Scrambler with Adjustable Phase Chirp”, IEEE Journal of Selected Topic in Quantum Electronics, Vol. 2, No. 2, June 1996, page 311-318).

1). With regard to claims 12 and 14, Chraplyvy et al discloses a method of DPSK transmission comprising:

modulating an optical signal according to a precoded electronic data signal (e.g., the modulator 105 drove by the electronic data from the encoder 313) by differential phase shift keying between two adjacent bits to generate DPSK signal; and

demodulate the DPSK using one bit delay line interferometer (Figure 5).

But, Chraplyvy et al does not disclose: to modulate the optical signal according to a precoded electronic data signal by differential phase shift keying between two optical bits separated by an even number of bit periods, and perform polarization alternating such that successive optical bits have substantially orthogonal polarizations to generate an APol-DPSK signal; wherein said modulating and said polarization alternating are performed simultaneously by a Mach-Zehnder modulator including a polarization rotation device in at least one arm, and wherein input signals to both arms of the Mach-Zehnder modulator have polarizations that are the same; and demodulating the APol-DPSK using an even bit delay line interferometer (claim 14).

However, it is well known in the art that the alternate polarization format with adjacent bits have orthogonal polarization can be used to significantly reduce the intrachannel nonlinear distortion. Hodzic teaches such a method to generate APol-RZ signal (alternate polarization return-to-zero signal) (Figure 1). Hodzic et al teaches a RZ coder, modulating the optical signal according to the RZ electronic data signal, performing polarization alternating of the RZ optical signal using a modulator (polarization modulator in Figure 1) such that successive optical bits have substantially orthogonal polarizations to generate an APol-RZ signal.

Hodzic discloses that the APol-RZ signals with orthogonal polarization between adjacent bits cause significant improvement of system performance through suppression of non-linear effects compared with RZ and NRZ format, the APol-RZ modulation format significantly improves the maximum input power, shows 7-10 dB improvement compared to RZ and NRZ format, the alternate polarization of adjacent bits reduces the power transfer between adjacent bits resulting also in suppression of intrachannel effects; and the APol-RZ possesses better PMD characteristics than RZ and NRZ, has better dispersion tolerance; the maximum transmission distance can be enhanced with factor of 2 by using this modulation method. Hodzic et al teaches that the alternate polarization format remains the best choice modulation format (page 155 left column).

As the polarization modulator as taught by Hodzic is applied to the DPSK format of Chraplyvy et al, that is, combine a polarization modulator with the phase modulator (105 in Figure 3 of Chraplyvy), it is obvious to one skilled in the art that the differential

encoder (e.g., 313 in Figure 3) needs to be set as a two-bit delay precoder and the demodulator (501 in Figure 5) needs to be a two-bit delay line interferometer: after the polarization modulator, the bits 1, 3, 5, … 2n-1 have one kind of polarization, and the bits 2, 4, 6, … 2n has another polarization which is orthogonal to the polarization of “odd” bits; at the receiver, theoretically, the “odd” bits and the “even” bits do not interfere (or coherently add or subtract) with each other at the balanced detector because they are orthogonally polarized. That is, the two sets of data bits can be treated independently; since bit “1” and bit “3” has a two-bit periods of time interval, to get the DPSK benefit and restore the original data, the bits 1, 3, 5, … 2n-1 need to be encoded by differentially phase shift keying between any two bits separated by two-bit slots (or even number of bit periods), so to generate “odd” bits conventional DPSK signal, same is for bits 2, 4, 6, … 2n. And to decode the DPSK signal or restore the original data, the 2-bit delay interferometer is needed since each set of data is encoded by two-bit delay at the transmitter.

To precode the data by two-bit delay is not new in the art; theoretically, the conventional DPSK format can be generate with differentially phase shift keying between any two bits separated by one bit slot, two-bit slots or other number of bit slots as long as the demodulator has the same number of bit delay. Snawerdt, in the same field of endeavor, teaches a system and method to generate a DPSK format with a precoder having delay of 2-bit slots (18 in Figures 1 and 2 generates the differential phase shift keying electronic signal, “OP” as shown in Figure 4 and 5, [0040] and [0046]). Snawerdt teaches to modulate the optical signal according to a precoded

electronic data signal (the signal outputted from the precoder 18 in Figure 1) by differential phase shift keying between two optical bits separated by an even number of bit periods ([0046]); and the precoded signal drives the phase modulator (16 in Figure 1), and an DPSK optical signal (encoded with two bits separated by two bits) is outputted from the phase modulator (22 in Figure 1, or [0046], phase modulator 16 converts the electronic data stream OP into optical signal 22 representative of OP); and a two-bit delay interferometer (40 in Figures 1 and 3) to demodulate the differential phase shift keying signal and get the original input data signal (DSO as shown in Figures 3-5).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the alternate polarization format and two-bit delay precoder and demodulator as taught by Hodzic et al and Snawerdt to the system of Chraplyvy et al so that a APol-DPSK modulation format can be obtained, and the intrachannel nonlinear distortion can be reduced, and system performance can be significantly enhanced, and the transmission distance can be significantly increased.

But, the combination of Chraplyvy et al and Hodzic et al and Snawerdt teaches two modulators: one for phase modulation and anther for polarization modulation. Chraplyvy et al and Hodzic et al and Snawerdt do not expressly teach a single Mach-Zehnder modulator including a polarization rotation device in at least one arm to perform simultaneously the modulating and polarization alternating and wherein input signals to both arms of the Mach-Zehnder modulator have polarizations that are the same.

However, Heismann et al, in the same field of endeavor, teaches a Mach-Zehnder modulator including a polarization rotation device (the 90 degree Rotated PMF in Figure 2) in at least one arm; the Mach-Zehnder modulator can provide simultaneous polarization alternation and optical phase modulation (Figure 2, equations (5), (7) and (10) etc., page 313-314), wherein input signals to both arms of the Mach-Zehnder modulator have polarizations that are the same (0 degree linear input SOP in Figure 2).

The phase difference between the two arms in Figure 2a is introduced by the phase modulation signal applied to the two arms. After the phase modulation, one arm is rotated 90 degree to make the polarization states of the components in the two arms orthogonal. The output Jones vectors of the device in Figure 2(a) is shown in Equations (5) and (10). The functional operation of the polarization alternator in Figure 2(a) is <u>similar to that of a phase modulator followed by a variable polarization rotator</u>. Heismann et al teaches that by varying the two drive voltage amplitude and the relative drive phase, <u>any desired combination of polarization and phase modulation can be produced</u>, and the phase relationship between the induced polarization and phase modulation can also be controlled (page 314, right column).

Since Chraplyvy et al and Snawerdt teaches to precode the electronic signal by differential phase shift keying, and the Mach-Zehnder modulator of Heismann can generate any desired phase modulation and polarization state. By combination of Chraplyvy et al and Hodzic and Snawerdt and Heismann, the Mach-Zehnder modulator of Heismann can be driven according to the precoded electronic signal of differential

phase shift keying with two bit delay so to provide simultaneously polarization alternation and phase encoding and generate the APol-DPSK signal.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the modulator as taught by Heismann et al to the system of Chraplyvy et al and Hodzic et al and Snawerdt so that an integrated monolithic modulator can be obtained and a high speed APol-DPSK can be generated with a single modulator, a simple structure system with simultaneous phase modulation and polarization alternation can be utilized, and system cost can be decreased.

2). With regard to claim 13, Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al disclose all of the subject matter as applied to claim 10 above, and Heismann et al further discloses wherein the polarization rotation device is a half-wave plate (the 90 degree rotated PMF in Heisman is a half-wave plate: retards one polarization by half wavelength or π phase retardation, so to rotate the polarization by 90 degree).

3). With regard to claim 26, Chraplyvy et al discloses an optical transmitter (Figure 3) for DPSK transmission comprising:

an optical source (DFB Laser 101 in Figure 3);

a precoder (e.g., the differential encoder 313 in Figure 3);

a Mach-Zehnder (MZ) modulator device optically coupled to the optical source (e.g., [0023] and [0026], the phase modulator 105 coupled to the laser source via pulse carver 103, the phase modulator 105 is a Mach-Zehnder modulator);

drive circuitry coupled to the MZ modulator device to drive the MZ modulator using a precoded data signal from the precoder (Figure 3, the electrical signal from the encoder to drive the phase modulator, that is, a drive circuitry is inherently present in the system so to drive the Mach-Zehnder to generate a DPSK signal, [0026]).

But, Chraplyvy et al does not disclose: an APol-DPSK transmitter, and the Mach-Zehnder (MZ) modulator device having a half-wave plate in one arm; wherein input signals to both arms of the Mach-Zehnder modulator have polarizations that are the same; and to drive the MZ modulator using a precoded data signal from the precoder to simultaneously provide polarization alternation and optical data encoding of an optical signal using differential phase shift keying between two optical bits separated by an even number of bit periods to generate an APol-DPSK signal.

However, it is well known in the art that the alternate polarization format with adjacent bits have orthogonal polarization can be used to significantly reduce the intrachannel nonlinear distortion. Hodzic teaches such a method to generate APol-RZ signal (alternate polarization return-to-zero signal) (Figure 1). Hodzic et al teaches a RZ coder or drive circuitry, modulating the output of an optical source using the RZ electronic data signal, alternating the polarization of the RZ optical signal using a modulator (polarization modulator in Figure 1) such that successive optical bits have substantially orthogonal polarizations to generate an APol-RZ signal.

Hodzic discloses that the APol-RZ signals with orthogonal polarization between adjacent bits cause significant improvement of system performance through suppression of non-linear effects compared with RZ and NRZ format, the APol-RZ

modulation format significantly improves the maximum input power, shows 7-10 dB improvement compared to RZ and NRZ format, the alternate polarization of adjacent bits reduces the power transfer between adjacent bits resulting also in suppression of intrachannel effects; and the APol-RZ possesses better PMD characteristics than RZ and NRZ, has better dispersion tolerance; the maximum transmission distance can be enhanced with factor of 2 by using this modulation method. Hodzic et al teaches that the alternate polarization format remains the best choice modulation format (page 155 left column).

As the polarization modulator as taught by Hodzic is applied to the DPSK format of Chraplyvy et al, that is, combine a polarization modulator with the phase modulator (105 in Figure 3 of Chraplyvy), it is obvious to one skilled in the art that the differential encoder (e.g., 313 in Figure 3) needs to be set as a two-bit delay precoder and the demodulator (501 in Figure 5) needs to be a two-bit delay line interferometer: after the polarization modulator, the bits 1, 3, 5, … 2n-1 have one kind of polarization, and the bits 2, 4, 6, … 2n has another polarization which is orthogonal to the polarization of “odd” bits; at the receiver, theoretically, the “odd” bits and the “even” bits do not interfere (or coherently add or subtract) with each other at the balanced detector because they are orthogonally polarized. That is, the two sets of data bits can be treated independently; since bit “1” and bit “3” has a two-bit periods of time interval, to get the DPSK benefit and restore the original data, the bits 1, 3, 5, … 2n-1 need to be encoded by differentially phase shift keying between any two bits separated by two-bit slots (or even number of bit periods), so to generate “odd” bits conventional DPSK signal, same

is for bits 2, 4, 6, … 2n. And to decode the DPSK signal or restore the original data, the 2-bit delay interferometer is needed since each set of data is encoded by two-bit delay at the transmitter.

To precode the data by two-bit delay is not new in the art; theoretically, the conventional DPSK format can be generate with differentially phase shift keying between any two bits separated by one bit slot, two-bit slots or other number of bit slots as long as the demodulator has the same number of bit delay. Snawerdt, in the same field of endeavor, teaches a system and method to generate a DPSK format with a precoder having delay of 2-bit slots (18 in Figures 1 and 2 generates the differential phase shift keying electronic signal, “OP” as shown in Figure 4 and 5, [0040] and [0046]), the precoded signal drives the Mach-Zehnder phase modulator (16 in Figure 1), and an DPSK optical signal (encoded using differential phase shift keying between two optical bits separated by two bits periods) is outputted from the phase modulator (22 in Figure 1, or [0046], phase modulator 16 converts the electronic data stream OP into optical signal 22 representative of OP); and a two-bit delay interferometer (40 in Figures 1 and 3) to demodulate the differential phase shift keying signal and get the original input data signal (DSO as shown in Figures 3-5).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the alternate polarization format and two-bit delay precoder and demodulator as taught by Hodzic et al and Snawerdt to the system of Chraplyvy et al so that a APol-DPSK modulation format can be obtained, and the

intrachannel nonlinear distortion can be reduced, and system performance can be significantly enhanced, and the transmission distance can be significantly increased.

But, the combination of Chraplyvy et al and Hodzic et al and Snawerdt teaches two modulators: one for phase modulation and anther for polarization modulation. Chraplyvy et al and Hodzic et al and Snawerdt do not expressly teach a single Mach-Zehnder (MZ) modulator device having a half-wave plate in one arm that can provide simultaneously polarization alternation and optical data encoding (phase modulation) of the optical signal.

However, Heismann et al, in the same field of endeavor, teaches a Mach-Zehnder modulator modulator device (Figure 2) having a half-wave plate in one arm (the 90 degree Rotated PMF in Figure 2); wherein input signals to both arms of the Mach-Zehnder modulator have polarizations that are the same (0 degree linear input SOP in Figure 2); and drive circuitry (the circuitry which generates V1 and V2 driving signals) coupled to the MZ modulator device to drive the MZ modulator to simultaneously provide polarization alternation and phase modulation (Figure 2, equations (5) (7) and (10), page 313-314).

The phase difference between the two arms in Figure 2a is introduced by the phase modulation signal applied to the two arms. After the phase modulation, one arm is rotated 90 degree to make the polarization states of the components in the two arms orthogonal. The output Jones vectors of the device in Figure 2(a) is shown in Equations (5) and (10). The functional operation of the polarization alternator in Figure 2(a) is <u>similar to that of a phase modulator followed by a variable polarization rotator</u>.

Heismann et al teaches that by varying the two drive voltage amplitude and the relative drive phase, any desired combination of polarization and phase modulation can be produced, and the phase relationship between the induced polarization and phase modulation can also be controlled (page 314, right column).

Since Chraplyvy et al and Snawerdt teaches to precode the electronic signal by differential phase shift keying, and the Mach-Zehnder modulator of Heismann can generate any desired phase modulation and polarization state. By combination of Chraplyvy et al and Hodzic and Snawerdt and Heismann, the Mach-Zehnder modulator of Heismann can be driven according to the precoded electronic signal of differential phase shift keying with two bit delay so to provide simultaneously polarization alternation and phase encoding and generate the APol-DPSK signal.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the modulator as taught by Heismann et al to the system of Chraplyvy et al and Hodzic et al and Snawerdt to the system of so that an integrated monolithic modulator can be obtained and a high speed APol-DPSK can be generated with the single modulator, a simple structure system with simultaneous phase modulation and polarization alternation can be utilized, and system cost can be decreased.

4). With regard to claim 19, Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al disclose all of the subject matter as applied to claim 26 above, and the combination of Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al further discloses wherein at least one arm of the Mach-Zehnder modulator is driven by a

sinusoidal RF voltage (e.g., Heismann: Figure 1 and 2, GHz sinusoidal RF voltage is applied to the at least one arm).

5). With regard to claim 20, Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al disclose all of the subject matter as applied to claim 26 above. And Hodzic et al further discloses that the phase modulator is driven by a RF clock signal running at half the bit rate (Figure 1b, 20 GHz clock signal, 40 Gb/s data signal). But Chraplyvy et al and Hodzic et al and Snawerdt and Heismann do not expressly disclose wherein at least one arm of the Mach-Zehnder modulator is driven by a train of square pulses.

However, it is well known in the art that the clock signal can be sinusoidal signal or a train of square pulses. And in Figure 4c, Chraplyvy et al discloses that a square-wave shape pulse can be used to drive the phase modulator.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply a train of square pulses to the phase modulator of the system of Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al so that the desired polarization and phase modulation can be obtained.

6). With regard to claim 21, Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al disclose all of the subject matter as applied to claim 26 above, and the combination of Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al further discloses wherein the Mach- Zehnder modulator comprises two complementary output ports (Heismann: Figure 2b, the two output ports after the 3-dB Directional Coupler: one connecting PMF and another connecting to 90 degree Rotated PMF), and

wherein the transmitter further comprises a polarization beam combiner (the PBS in Figure 2b) for combining outputs from the two output ports of the Mach-Zehnder modulator (Figure 2b, the PBS combines the two output ports from the MZ modulator).

7). With regard to claim 22, Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al disclose all of the subject matter as applied to claims 26 and 21 above, and the combination of Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al further discloses wherein at least one arm of the Mach-Zehnder modulator is driven by a sinusoidal RF voltage (e.g., Heismann: Figure 1 and 2, GHz sinusoidal RF voltage is applied to the at least one arm).

8). With regard to claim 23, Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al disclose all of the subject matter as applied to claims 26 and 21 above. And Hodzic et al further discloses that the phase modulator is driven by a RF clock signal running at half the bit rate (Figure 1b, 20 GHz clock signal, 40 Gb/s data signal). But Chraplyvy et al and Hodzic et al and Snawerdt and Heismann do not expressly disclose wherein at least one arm of the Mach-Zehnder modulator is driven by a train of square pulses.

However, it is well known in the art that the clock signal can be sinusoidal signal or a train of square pulses. And in Figure 4c, Chraplyvy et al discloses that a square-wave shape pulse can be used to drive the phase modulator.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply a train of square pulses to the phase modulator of

the system of Chraplyvy et al and Hodzic et al and Snawerdt and Heismann et al so that the desired polarization and phase modulation can be obtained.

6. Claims 9, 25 and 28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chraplyvy et al (US 2003/0007216) in view of Hodzic et al (Hodzic et al: "Improvement of System Performance in N x 40-Gb/s WDM Transmission Using Alternate Polarizations", IEEE Photonics Techmology Letters, Vol. 15, No. 1, Jan 2003, pages 153-155) and Heismann et al (Heismann et al: “High-Speed Polarization Scrambler with Adjustable Phase Chirp”, IEEE Journal of Selected Topic in Quantum Electronics, Vol. 2, No. 2, June 1996, page 311-318).

1). With regard to claim 9, Chraplyvy et al discloses a method of PSK transmission comprising the steps of:

providing a coherently polarized optical source signal (Figure 1, the continue wave distributed feedback laser, CW-DFB laser, generates a coherently polarized optical signal) to the arms of a Mach-Zehnder modulator (the optical signal is provided to the arms the phase modulator 105, which is a Mach-Zehnder modulator, via a pulse carver 103, [0023]),

encoding the optical source signal by phase shift keying to generate a phase encoded signal (Figures 1 and 2, the optical source signal is encoded by phase shift keying to generate a phase encoded signal, [0021]-[0024], Figure 2d shows the PSK signal), wherein said phase shift keying is performed by driving the Mach-Zehnder modulator with an electronic data signal (the electronic signal from the Data In 111

drives the Mach-Zehnder phase modulator 105 to generate the PSK signal, [0023] and [0024]); and

But, Chraplyvy et al does not disclose: an APol-PSK transmission, and the Mach-Zehnder modulator has a polarization rotation device in at least one arm and configured to provide simultaneous polarization alternation and optical data encoding by phase shift keying; and alternating the polarization of every other bit simultaneous with the step of encoding the optical source signal to produce an APol-PSK signal, wherein said alternating is performed by the Mach-Zehnder modulator.

However, it is well known in the art that the alternate polarization format with adjacent bits have orthogonal polarization can be used to significantly reduce the intrachannel nonlinear distortion. Hodzic teaches such a method to generate APol-RZ signal (alternate polarization return-to-zero signal) (Figure 1). Hodzic et al teaches a RZ coder, modulating the input optical signal by the RZ electronic data signal, alternating the polarization of the RZ optical signal using a modulator (polarization modulator in Figure 1) such that successive optical bits have substantially orthogonal polarizations to generate an APol-RZ signal.

Hodzic discloses that the APol-RZ signals with orthogonal polarization between adjacent bits cause significant improvement of system performance through suppression of non-linear effects compared with RZ and NRZ format, the APol-RZ modulation format significantly improves the maximum input power, shows 7-10 dB improvement compared to RZ and NRZ format, the alternate polarization of adjacent bits reduces the power transfer between adjacent bits resulting also in suppression of

intrachannel effects; and the APol-RZ possesses better PMD characteristics than RZ and NRZ, has better dispersion tolerance; the maximum transmission distance can be enhanced with factor of 2 by using this modulation method. Hodzic et al teaches that the alternate polarization format remains the best choice modulation format (page 155 left column).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the polarization alternation as taught by Hodzic et al to the system of Chraplyvy et al so that a APol-PSK modulation format can be obtained, and the intrachannel nonlinear distortion can be reduced, and system performance can be significantly enhanced, and the transmission distance can be significantly increased.

But, the combination of Chraplyvy et al and Hodzic et al teaches two modulators: one for phase modulation and anther for polarization modulation. Chraplyvy et al and Hodzic et al do not expressly teach a single Mach-Zehnder modulator having a polarization rotation device in at least one arm to provide simultaneously polarization alternation and optical data encoding.

However, Heismann et al, in the same field of endeavor, teaches a Mach-Zehnder modulator having a polarization rotation device (the 90 degree Rotated PMF in Figure 2) in at least one arm; the Mach-Zehnder modulator can provide simultaneous polarization alternation and optical phase modulation (Figure 2, equations (5), (7) and (10) etc., page 313-314).

The phase difference between the two arms in Figures 2a or 2b is introduced by the phase modulation signal applied to the two arms. After the phase modulation, one arm is rotated 90 degree to make the polarization states of the components in the two arms orthogonal. The output Jones vectors of the device in Figure 2(a) is shown in Equations (5) and (10). The functional operation of the polarization alternator in Figure 2(a) is <u>similar to that of a phase modulator followed by a variable polarization rotator</u>. Heismann et al teaches that by varying the two drive voltage amplitudes and the relative drive phase, <u>any desired combination of polarization and phase modulation can be produced</u>, and the phase relationship between the induced polarization and phase modulation can also be controlled (page 314, right column).

Since Chraplyvy et al teaches to precode the electronic signal by phase shift keying, and the Mach-Zehnder modulator of Heismann can generate any desired phase modulation and polarization state. By combination of Chraplyvy et al and Hodzic and Heismann, the Mach-Zehnder modulator of Heismann can be driven according to the precoded electronic signal of the phase shift keying to provide simultaneously polarization alternation and phase encoding and generate the APol-PSK signal.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the Mach-Zehnder modulator as taught by Heismann et al to the system of Chraplyvy et al and Hodzic et al so that an integrated monolithic modulator can be obtained and a high speed APol-PSK can be generated with a single modulator, a simple structure system with simultaneous phase modulation and polarization alternation can be utilized, and system cost can be decreased.

2). With regard to claim 25, Chraplyvy et al discloses an optical transmitter (Figures 1 and 2) for PSK transmission comprising:

an optical source (the DFB Laser 101 in Figure 1);

a Mach-Zehnder (MZ) modulator device optically coupled to the optical source (the phase modulator 105, which is a Mach-Zehnder modulator coupled to the optical source via the pulse carver 103, [0023]); and

drive circuitry coupled to the MZ modulator device to drive the MZ modulator (Figure 1, the electrical signal from the Data Input 101 to drive the phase modulator, that is, a drive circuitry is inherently present in the system so to drive the Mach-Zehnder to generate a PSK signal, [0023] and [0024]) to provide optical data encoding of an optical signal using phase shift keying to generate a PSK signal (Figures 1 and 2, the optical source signal is encoded by phase shift keying to generate a phase shift keying signal, [0021]-[0024], Figure 2d shows the PSK signal).

But, Chraplyvy et al does not disclose: an APol-PSK transmitter, and the Mach-Zehnder modulator has a polarization rotation device in one arm and to simultaneously provide polarization alternation and optical data encoding of the optical signal using phase shift keying to generate an APol-PSK signal, wherein input signals to both arms of the Mach-Zehnder modulator have polarizations that are the same.

However, it is well known in the art that the alternate polarization format with adjacent bits have orthogonal polarization can be used to significantly reduce the intrachannel nonlinear distortion. Hodzic teaches such a method to generate APol-RZ signal (alternate polarization return-to-zero signal) (Figure 1). Hodzic et al teaches a RZ

coder, modulating the input optical signal by the RZ electronic data signal, alternating the polarization of the RZ optical signal using a modulator (polarization modulator in Figure 1) such that successive optical bits have substantially orthogonal polarizations to generate an APol-RZ signal.

Hodzic discloses that the APol-RZ signals with orthogonal polarization between adjacent bits cause significant improvement of system performance through suppression of non-linear effects compared with RZ and NRZ format, the APol-RZ modulation format significantly improves the maximum input power, shows 7-10 dB improvement compared to RZ and NRZ format, the alternate polarization of adjacent bits reduces the power transfer between adjacent bits resulting also in suppression of intrachannel effects; and the APol-RZ possesses better PMD characteristics than RZ and NRZ, has better dispersion tolerance; the maximum transmission distance can be enhanced with factor of 2 by using this modulation method. Hodzic et al teaches that the alternate polarization format remains the best choice modulation format (page 155 left column).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the polarization alternation as taught by Hodzic et al to the system of Chraplyvy et al so that a APol-PSK modulation format can be obtained, and the intrachannel nonlinear distortion can be reduced, and system performance can be significantly enhanced, and the transmission distance can be significantly increased.

But, the combination of Chraplyvy et al and Hodzic et al teaches two modulators: one for phase modulation and anther for polarization modulation. Chraplyvy et al and Hodzic et al do not expressly teach a single Mach-Zehnder modulator having a polarization rotation device in at least one arm to provide simultaneously polarization alternation and optical data encoding.

However, Heismann et al, in the same field of endeavor, teaches a Mach-Zehnder modulator having a polarization rotation device (the 90 degree Rotated PMF in Figure 2) in at least one arm; the Mach-Zehnder modulator can provide simultaneous polarization alternation and optical phase modulation (Figure 2, equations (5), (7) and (10) etc., page 313-314); wherein input signals to both arms of the Mach-Zehnder modulator have polarizations that are the same (0 degree linear input SOP in Figure 2).

The phase difference between the two arms in Figures 2a or 2b is introduced by the phase modulation signal applied to the two arms. After the phase modulation, one arm is rotated 90 degree to make the polarization states of the components in the two arms orthogonal. The output Jones vectors of the device in Figure 2(a) is shown in Equations (5) and (10). The functional operation of the polarization alternator in Figure 2(a) is similar to that of a phase modulator followed by a variable polarization rotator. Heismann et al teaches that by varying the two drive voltage amplitudes and the relative drive phase, any desired combination of polarization and phase modulation can be produced, and the phase relationship between the induced polarization and phase modulation can also be controlled (page 314, right column).

Since Chraplyvy et al teaches to precode the electronic signal by phase shift keying, and the Mach-Zehnder modulator of Heismann can generate any desired phase modulation and polarization state. By combination of Chraplyvy et al and Hodzic and Heismann, the Mach-Zehnder modulator of Heismann can be driven according to the precoded electronic signal of the phase shift keying to simultaneously provide polarization alternation and phase encoding to generate the APol-PSK signal.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the Mach-Zehnder modulator as taught by Heismann et al to the system of Chraplyvy et al and Hodzic et al so that an integrated monolithic modulator can be obtained and a high speed APol-PSK can be generated with a single modulator, a simple structure system with simultaneous phase modulation and polarization alternation can be utilized, and system cost can be decreased.

3). With regard to claim 28, Chraplyvy et al discloses an optical transmission system (Figures 1 and 2) for PSK transmission comprising:

an optical source (the DFB Laser 101 in Figure 1),

a modulator means (the PSK Modulator 105 in Figure 1) to provide optical data encoding by phase shift keying to generate an PSK signal (the electronic signal from the Data In 111 drives the Mach-Zehnder phase modulator 105 to generate the PSK signal, [0023] and [0024]; the optical source signal output from the MZ phase modulator is encoded by phase shift keying, [0021]-[0024], Figure 2d shows the PSK signal).

But, Chraplyvy et al does not disclose: an APol-PSK transmission, and the Mach-Zehnder modulator has a polarization rotation device to provide simultaneous

polarization alternation and optical data encoding by phase shift keying to generate an APol-PSK signal.

However, it is well known in the art that the alternate polarization format with adjacent bits have orthogonal polarization can be used to significantly reduce the intrachannel nonlinear distortion. Hodzic teaches such a method and system to generate APol-RZ signal (alternate polarization return-to-zero signal) (Figure 1). Hodzic et al teaches a RZ coder, modulating the input optical signal by the RZ electronic data signal, alternating the polarization of the RZ optical signal using a modulator (polarization modulator in Figure 1) such that successive optical bits have substantially orthogonal polarizations to generate an APol-RZ signal.

Hodzic discloses that the APol-RZ signals with orthogonal polarization between adjacent bits cause significant improvement of system performance through suppression of non-linear effects compared with RZ and NRZ format, the APol-RZ modulation format significantly improves the maximum input power, shows 7-10 dB improvement compared to RZ and NRZ format, the alternate polarization of adjacent bits reduces the power transfer between adjacent bits resulting also in suppression of intrachannel effects; and the APol-RZ possesses better PMD characteristics than RZ and NRZ, has better dispersion tolerance; the maximum transmission distance can be enhanced with factor of 2 by using this modulation method. Hodzic et al teaches that the alternate polarization format remains the best choice modulation format (page 155 left column).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the polarization alternation as taught by Hodzic et al to the system of Chraplyvy et al so that a APol-PSK modulation format can be obtained, and the intrachannel nonlinear distortion can be reduced, and system performance can be significantly enhanced, and the transmission distance can be significantly increased.

But, the combination of Chraplyvy et al and Hodzic et al teaches two modulators: one for phase modulation and anther for polarization modulation. Chraplyvy et al and Hodzic et al do not expressly teach a <u>single</u> Mach-Zehnder modulator having a polarization rotation device to provide simultaneous polarization alternation and optical data encoding.

However, Heismann et al, in the same field of endeavor, teaches a Mach-Zehnder modulator having a polarization rotation device (the 90 degree Rotated PMF in Figure 2); the Mach-Zehnder modulator can provide simultaneous polarization alternation and optical phase modulation (Figure 2, equations (5), (7) and (10) etc., page 313-314).

The phase difference between the two arms in Figures 2a or 2b is introduced by the phase modulation signal applied to the two arms. After the phase modulation, one arm is rotated 90 degree to make the polarization states of the components in the two arms orthogonal. The output Jones vectors of the device in Figure 2(a) is shown in Equations (5) and (10). The functional operation of the polarization alternator in Figure 2(a) is <u>similar to that of a phase modulator followed by a variable polarization rotator</u>.

Heismann et al teaches that by varying the two drive voltage amplitudes and the relative drive phase, any desired combination of polarization and phase modulation can be produced, and the phase relationship between the induced polarization and phase modulation can also be controlled (page 314, right column).

Since Chraplyvy et al teaches to precode the electronic signal by phase shift keying, and the Mach-Zehnder modulator of Heismann can generate any desired phase modulation and polarization state. By combination of Chraplyvy et al and Hodzic and Heismann, the Mach-Zehnder modulator of Heismann can be driven according to the precoded electronic signal of the phase shift keying to provide simultaneously polarization alternation and phase encoding and generate the APol-PSK signal.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the Mach-Zehnder modulator as taught by Heismann et al to the system of Chraplyvy et al and Hodzic et al so that an integrated monolithic modulator can be obtained and a high speed APol-PSK can be generated with a single modulator, a simple structure system with simultaneous phase modulation and polarization alternation can be utilized, and system cost can be decreased.

Conclusion

7. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Xie et al (Xie et al: "Suppression of Intrachannel Nonlinear Effects With Alternate-Polarization Format", Journal of Lightwave Technology, Vol. 22, No. 3, March 2004, pages 806-812).

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to LI LIU whose telephone number is (571)270-1084. The examiner can normally be reached on Monday-Friday, 8:30 am - 6:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ken Vanderpuye can be reached on (571)272-3078. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Li Liu/
Examiner, Art Unit 2613
April 5, 2009